Flora and ecological characteristics of rare plant communities on the southern slope of Shennongjia Mountain

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Abstract: According to the investigation of sampling area of 6800 m^2 on the south slope of Shennongjia Mountain, there were 126 vascular plant species, belonging to 108 genera and 64 families, in the investigated rare plant communities, of which 9 rare plant species were recorded, accounting for 27.3% of the total rare plants. The communities were about 30 m in height and were divided into three layers as tree layer, shrub layer, and herb layer. The flora of the communities had obvious temperate character. Phanerophytes (accounted for 65.9%), Mesophyllous (62.7%), Papyraceous (84.1%), simple leaf (83.3%), un-entire leaf (69.8%) were dominant in life form, leaf size class, leaf texture, leaf form, and leaf margin respectively. According to important value of species, the communities were divided into three types as *Davidia involucrata* + *Litsea pungens* community, *Cercidiphyllum japanicum* + *Padus wilsonii* community, and *Padus wilsonii* + *Acer mono* community. The indexes of species diversity of tree layer had little difference among communities and evenness was high. The results indicated that the communities had complex structure and relative stability.

Keywords: Rare plant community; Flora; Ecological characteristics; Shennongjia Mountain
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Introduction

Conservation biology is a new discipline, and conservation of rare plants is an important aspect (Jiang *et al.* 1998). Some species are naturally rare and are able to persist in nature in small populations. The type of rarity depends on three attributes of the species: (1) size of geographical range (large *v.* small); (2) habitat specificity (wide *v.* narrow); (3) local population size (high *v.* low) (Mackenzie *et al.* 1998). To protect rare plants, it is necessary to study the factors, which influence the quantity of rare plants. Habitat degradation often results in the decline or loss of species, and habitat fragmentation reduces the habitat area and increases the distance between remaining patches (Mackenzie *et al.* 1998). At present, the relative studies on rare plant conservation are mainly focused on community structure, species component, competition, and habitat demand (Schemske 1994).

Shennongjia Mountain is located in the transitional terrain from north subtropical zone to warm temperate zone, where there exist multiple habitats. Since the Fourth Glacial Epoch, this area has been avoided the direct attack of glacier and become the refuge for many ancient plants due to aegis of Qinling Mountain and Daba Mountain. But now, forest vegetation and species resources in the area were severely destroyed owing to the increase of economic activities and population. The area of evergreen broadleaved forest and evergreen and deciduous mixed broadleaved forest below elevation of 1 600 m was increasingly reduced. How to protect the rare plants in this area is very important, and most studies were focused on distribution of rare plants (Li 1992) and describing characteristics of individual rare plant community (Wuhan Institute of Botany 1980). In this study, rare plants distributed on the south slope of Shennongjia Mountain were studied from the viewpoint of community ecology, and it would offer a scientific base for rare plant conservation in this area.

Study sites and methods

Study area

Shennongjia Mountain is located at the north bank of Yangtze River and Northwest Hubei Province, and its geographic location is between latitude 31º15'-31º57'N and longitude 110º56'-110º58'E. The south slope is near to the Three Gorges. On the south slope, the maximum elevation is 3 105 m and the minimum elevation is 200 m. The study area was located in DuiziChang Village, Badong County, and the sampling quadrats were located in a ravine at elevation of 1 400-1 500 m on the south slope of Shennongjia Mountain. Forest vegetation is conserved perfectly in the investigated area owing to inconvenient traffic. The mean annual temperature is 9 ºC and the soil is mountainous

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yellow and palm soil.

Methods

Based on the complete exploration on distribution of rare plants, two 40m×40 m quadrats and one 60m×60 m quadrat were investigated, and the total sampling area was 6 800 m^2. In each quadrat, basic status such as altitude, slope direction and degree, and total coverage were recorded at first. Each tree in the quadrats was measured with species, height, and crown, and located in the plotting paper. Mean height and coverage were investigated for each shrub species and herb species.

Life form of plants in quadrats was analyzed according to Raunkiaer's classification system, and flora component was analyzed according to distribution area types (Wu 1991). Important value (P_i) was calculated by general method (Wang *et al.* 1996). Species richness (S), Simpson index (D), Shannon-Weiner index (H), species evenness (E), and probability of inter-population encounter (PIE) (Wang *et al.* 1996) were used to study the biodiversity of species in the tree layer.

$$D = \frac{N(N-1)}{\sum_{i=1}^{S} n_i(n_i-1)} \quad (1)$$

$$H = -\sum_{i=1}^{S} p_i \ln p_i \quad (2)$$

$$E = \frac{H}{\ln S} \quad (3)$$

$$PIE = \sum_{i=1}^{S} \frac{n_i(N-n_i)}{N(N-1)} \quad (4)$$

where P_i and n_i were important value and total individual of species i, and N was the total individual of all species.

Results

Species component of rare plant communities

According to the investigation data, there were 126 vascular plant species belonging to 108 genera and 64 families in the sampling quadrats. Among them, there were 3 pteridophyte species belonging to 3 genera and 2 families (Table 1).

Table 1. Number of family, genera, and species in rare plant communities on the southern slope of Shennongjia Mountain

Type	Family	Genera	Species			
			Wood	Herb	Liane	Total
Pteridophyte	2 (3.1%)	3 (2.8%)	0	3 (6.5%)	0	3 (2.4%)
Gymnosperm	3 (4.7%)	3 (2.8%)	3 (4.4%)	0	0	3 (2.4%)
Dicotyls	55 (85.9%)	93 (86.1%)	65 (95.6%)	34 (73.9%)	11 (91.7%)	110 (87.3%)
Monocotyls	4 (6.3)	9 (8.3%)	0	9 (19.6%)	1 (8.3%)	10 (7.9%)
Total	64 (100%)	108 (100%)	68 (100%)	46 (100%)	12 (100%)	126 (100%)

The families of Rosaceae and Saxifragaceae had 7 species respectively. The families that contain more than 5 species were Aceraceae (6 species), Caprifoliaceae (6 species), and Liliaceae (6 species). These families above included 32 species, accounting for 25.4% of total species in the communities. The main families containing 2-5 species were Fagaceae, Ranunculaceae, and Cornaceae, *et al*, and included 51 species, which was accounted for 40.5% of the total species. There were 43 families containing only one species, accounting for 34.1% of the total species. In the sampling quadrats, there were 9 rare plant species (Table 2), and making up 27.3% of the total 33 rare plant species in Shennongjia Area (Zheng *et al.* 1998). Among the 9 rare plant species, one species (*Davidia involucrata*) was in the first-class protection, three species (*Tetracentron sinensis*, *Cercidiphyllum japonicum*, and *Sinowilsonia henryi*) were in the second-class protection, and five species (*Corylus chinensis*, *Euptelea pleiospermum*, *Tapiscia sinensis*, *Dipteronia sinensis*, and *Pterostyrax psilophylla*) were in the third-class protection. In addition, there was one species (*Aesculus wilsonii)* in Hubei provincial class protection.

Table 2. Rare plants in the investigated quadrats

Name	Protection class
Davidia involucrate	I
Tetracentron sinensis	II
Cercidiphyllum japonicum	II
Sinowilsonia henryi	II
Corylus chinensis	III
Euptelea pleiospermum	III
Tapiscia sinensis	III
Dipteronia sinensis	III
Pterostyrax psilophylla	III

Flora of rare plant communities

According to the distribution area types (Wu 1991), 105 genera of spermatophyte in the sampling quadrats were analyzed (Table 3). The results showed that, of the 15 distribution area types existed in Shennongjia Area (Zheng *et al.* 1998), 11 types were found in the rare plant communities, and the species component was multiple and complex. Among the 105 genera, there were 29 genera of tropic distribution (Pantropic, Trop. Asia & Trop. Amer.

distribution (Pantropic, Trop. Asia & Trop. Amer. Disjuncted, Old World tropics, Tropical Asia & Trop. Australia, Trop. Asia to Trop. Africa, and Trop. Asia) and 64 genera of temperate distribution (North Temperate, East Asia & North Amer. Disjuncted, Old World Temperate, Temperate Asia, Mediterranean & West Asia to Central Asia, Central Asia, and East Asia), which were accounted for 27.6% and 61.0% of the total genera, respectively, and genera of temperate distribution was obviously dominant. Among the genera of temperate distribution, number of genera of North Temperate distribution was 29, included *Acer*, *Betula*, *Viburnum*, *Sorbus*, *Carpinus*, and *Quercus*, etc.. In the next place, number of genera of East Asia distribution was 23, included *Tetracentron*, *Pterostyrax*, *Cercidiphylum*, and *Kerria*, etc.. In brief, the rare plant communities had a temperate characteristic, and it was consistent with the flora of the whole Shennongjia Area (Zheng *et al.* 1998).

Table 3. Distribution area types of the spermatophyte in rare plant communities

Distribution area types	Number of genera in rare plant communities	Number of genera in Shennongjia Area
Cosmopolitan	8 (7.6%)	59 (7.5%)
Pantropic	9 (8.6%)	96 (2.1%)
Trop. Asia & Trop. Amer. disjuncted	3 (2.9%)	11 (1.4%)
Old World tropics	4 (3.8%)	27 (3.4%)
Tropical Asia & Trop. Australia	0	23 (2.9%)
Trop. Asia to Trop. Africa	3 (2.9%)	22 (2.8%)
Trop. Asia	10 (9.5%)	47 (5.9%)
North Temperate	29 (27.6%)	187 (23.6%)
East Asia & North Amer. Disjuncted	11 (10.5%)	67 (8.5%)
Old World Temperate	1 (1.0%)	60 (7.6%)
Temperate Asia	0	17 (2.1%)
Mediterranean, West Asia to Central Asia	0	4 (0.5%)
Central Asia	0	2 (0.3%)
East Asia	23 (21.9%)	117 (14.8%)
Endemic to China	4 (3.8%)	52 (6.6%)
Total	105 (100%)	791 (100%)

Physiognomy of rare plant communities

Seasonal change of physiognomy of rare plant community was obvious. In general, community physiognomy depends on synusia structure, namely life form component. Table 4 showed the life form spectra of the rare plant community. The result showed that phanerophytes was dominant in life form, accounted for 65.9%, and hemicryptophytes was the second.

Table 4. Life form spectra (%) of the rare plant communities and comparison to other communities

Community type	Phanerophytes	Chamaephytes	Hemicryptophytes	Cryptophytes	Therophytes	Liane
Rare plant community in Shennongjia	65.9	3.9	19.8	3.2	1.6	5.6
Evergreen broadleaved forest in Wuyanling, Zhejiang	72.2	0	12.5	2.8	0.6	11.9
Temperate deciduous broadleaved forest in Qingling Mt.	52.0	5.0	38.0	3.7	1.3	0

Characteristics of leave were important aspect of community physiognomy. Mesophyllous in leaf size class was dominant, accounted for 62.7%, and microphyllous was the second, accounted for 27.8%. Simple leaf, which accounted for 83.3%, was dominant in leaf form, and it reflected the primitivity of the rare plant community. Papyraceous was dominant in leaf texture, accounted for 84.1%, and leathern was the second, accounted for 11.1%. The characteristic of leaf texture showed that the rare plant community had property of deciduous broadleaved forest. Un-entire leaf was dominant in leaf margin type, accounted for 69.8%.

The rare plant communities was about 30 m in height, and had a distinct stratification, which could be divided into three layers as tree layer, shrub layer, and herb layer. Tree layer was the main layer. Height and coverage of tree layer were 6-30 m and 80% respectively. Height of shrub layer was about 2.5 m, and the coverage was 30%. The herb layer was not developed, and its coverage was about 15%.

Biodiversity of rare plant communities

Important value, which is often used to determine dominant species and constructive species, is a synthetic index on ecological adaptability and position of species in community. According to important value, the investigated communities could be divided into three types as *Davidia involucrata* + *Litsea pungens* community, *Cercidiphyllum japanicum* + *Padus wilsonii* community, and *Padus wilsonii* + *Acer mono* community. In the former two communities, rare plant species were dominant species, and in the latter community, rare plant species were main companion species.

Species diversity is an important index to measure species richness and distribution evenness in the habitat, and it is influenced by several biological and abiological factors. Studying species diversity can open out the relationship among different species and reflect species component in the community. Table 5 showed different biodiversity indexes of tree layer in the three communities. The results showed that most biodiversity indexes varied in a narrow range and had no significant difference.

Table 5. Biodiversity of the rare plant communities

Community type	D	H	E	PIE
Davidia involucrata + Litsea pungens community	10.1739	1.1173	0.8205	0.9017
Cercidiphyllum japanicum + Padus wilsonii community	15.7058	1.275	0.881	0.9363
Padus wilsonii + Acer mono community	12.283	1.20	0.8485	0.9186

Note: D: Simple index; H: Shannon-Weiner index; E: Species evenness; PIE: Probability of inter-population encounter.

Number and individual quantity of species in community reflected the structural characteristics and stability of the community to a certain extent. While a community had more species and the species were distributed evenly, there existed complex relationship among the species, which resulted in a relative equilibrium and stability of the community. The rare plant communities on the south slope of Shennongjia Mountain had high biodiversity, and it showed that the communities were complex in structure and relatively stable in development.

Conclusion

There were 126 vascular plant species belonging to 108 genera and 64 families in the investigated rare plant communities on the south slope of Shennongjia Mountain. Among them, 9 rare plant species, accounting for 27.3% of the total rare plants in Shennongjia Mountain, were recorded. The height of the communities was about 30 m, and it could be divided into three layers as tree layer, shrub layer, and herb layer. The flora of the communities had obvious temperate character. Phanerophytes was dominated in life form and accounted for 65.9%, and hemicryptophytes was the second. Mesophyllous in leaf size class was dominant and accounted for 62.7%, and microphyllous was the second. Simple leaf, which accounted for 83.3%, and un-entire leaf, which accounted for 69.8%, was dominant in leaf form and leaf margin respectively. According to important value of species, the communities could be divided into three types as *Davidia involucrata + Litsea pungens* community, *Cercidiphyllum japanicum + Padus wilsonii* community, and *Padus wilsonii + Acer mono* community. The indexes of species diversity of tree layer had little difference among communities and evenness was high. The results indicated that the communities had complex structure and relative stability.

Recently, exploitation and other human activities were increased in this area, and it certainly would influence the rare plant communities. Therefore, some further studies and protection measures should be carried out.

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